REMARKS

By this Amendment, claim 15 has been canceled, claims 14, 16, 17 and 19-23 have been amended and new claims 26 and 27 have been added. Accordingly, claims 14 and 16-27 are pending in the application. Claims 14, 20 and 26 are the independent claims. In view of the above amendments and the following remarks, favorable reconsideration of this application is respectfully requested.

The Examiner objected to the specification and to claim 19 as containing informalities, the latter of which Applicants have corrected herein. Applicants note that the sections added to the specification by the Amendment filed March 27, 2003, were properly presented, and have provided the text herein as previously amended for clarification and reconsideration by the Examiner.

The Examiner rejected claims 14, 17, 20 and 24 under 35 U.S.C. 102(b) as being anticipated by WO 98/50091, and rejected claims 15 and 21-23 under 35 U.S.C. 103(a) as being unpatentable over WO 98/50091 in view of "Hemodialysis Machines and Monitors" by Polaschegg et al. ("Polaschegg"). The Examiner further rejected claim 16 as being unpatentable over WO 98/50091 in view of Pedrini et al. ("Pedrini"), and claim 25 as being unpatentable

over WO 98/50091 in view of German Patent No. 4240681. The Examiner objected to claims 18 and 19 as being dependent upon a rejected base claim, but stated that these claims would be allowable if rewritten in independent form including all the limitations of the base claim and any intervening claims.

As set forth in amended claims 14 and 20, the present invention is directed to a method and apparatus for blood purification using a hemodialysis and/or hemofiltration apparatus with an extra-corporeal blood circuit for receiving blood to be purified and a hemodialyser and/or hemofilter communicating with the blood circuit. The blood circuit has an upstream supply line and a downstream supply line connected upstream and downstream, respectively, of the hemodialyser and/or hemofilter for supplying a substitution fluid. A measuring device, which is monitored by a control device, is used to detect and record at least one operational and/or blood parameter within the received blood, the parameter being selected from the group consisting of trans-membrane pressure, hematocrit value and blood density. In response to the detected parameter value, the infusion rate ($Q_S$pre) of the upstream supply line and the infusion rate ($Q_S$post) of the downstream supply line are controlled by the control device in order to control the operational and/or blood

parameter being measured. Thus, the controlled variable is one of trans-membrane pressure, hematocrit value or blood density as measured within the blood.

To clarify the distinctions of the present invention over WO 98/50091, Applicants have prepared and provided with this Amendment an English language translation of WO 98/50091. WO 98/50091 is directed to a method for controlling a blood purifying device by monitoring the operation of various pumps and scales within the device to ensure proper functioning of such mechanisms. Particularly, the weight of first and second substitution products contained in reservoirs 15, 16 is monitored, as is the weight of the ultrafiltrate extracted from the blood and thence placed in collection container 17 on scale 7 (see page 11, last paragraph). Actual values from the scales 5, 6, 7 are compared with theoretical values which should be obtained for each of the respective pumps, assuming normal function, to determine if the pumps are operating properly. There is no measurement of an operational and/or blood parameter value as measured within the blood, as claimed by the present invention, but only comparison of actual first and second product weights and ultrafiltrate weight with corresponding theoretical weights to verify that the pumps are operating as expected. When

actual values do not correspond with expected values, the pump rates are adjusted and, depending upon the magnitude of the difference, an alarm may be initiated (see page 14).

Clearly, WO 98/50091 does not teach or suggest the control system of the present invention in which one of a specified operational and/or blood parameter is measured *within* the blood and the parameter value thereof controlled through adjustment of the infusion rates of the substitution fluid within pre- and post-substitution fluid supply lines.

Polaschegg teaches adjustment of an operational parameter, such as transmembrane pressure, for the purpose of controlling an ultrafiltration rate, but does not teach or suggest modifying the infusion rates of pre- and post-substitution fluid supply lines to control the blood parameter. Nor is there anything in WO 98/50091 or Polaschegg which would suggest modifying WO 98/50091 to include sensors for measuring trans-membrane pressure, hematocrit value or blood density.

As just explained, WO 98/50091 relies upon the measured and theoretical weights of first and second substitution fluids, as well as the weight of ultrafiltrate extracted, to monitor the operation of pump devices within a hemofiltration system (see page 4, last paragraph, through first full paragraph on page 6).

There is no provision for or description of how such a system could be modified to measure trans-membrane pressure, hematocrit value or blood density as these parameters are not determined by extraction from the blood and weighing thereof. Even if such modification could be made, there is no incentive to do so as determining the weight of the products and ultrafiltrate is simpler and achieves the intended goal of monitoring the correct operation of the pumps. Furthermore, that the blood parameters of trans-membrane pressure, hematocrit value or blood density may have been used in conjunction with ultrafiltration systems generally, as discussed in Polaschegg, does not teach how the measurement of such parameters can be used to control the infusion rates of substitution fluid within pre- and post-substitution fluid supply lines of a hemodialysis and/or hemofiltration device in the specific manner being claimed, except with the benefit of Applicants' own disclosure, which cannot be properly relied upon.

For at least the foregoing reasons, claims 14 and 20 are not shown or suggested by WO 98/50091, either alone or in combination with Polaschegg, and are patentable thereover. Claims 16-19 and 21-25 are also in condition for allowance as

claims properly dependent on an allowable base claim and also for the subject matter contained therein.

New claim 26 represents the subject matter of claim 18 rewritten in independent form and is in condition for allowance in accordance with the Examiner's identification of allowable subject matter. Claim 27 is also in condition for allowance as a claim properly dependent on an allowable base claim and for the subject matter contained therein.

Entry of the amendment and allowance of the pending claims is requested. Should the Examiner have any questions or comments, the Examiner is cordially invited to telephone the undersigned attorney so that the present application can receive an early Notice of Allowance.

Respectfully submitted,

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METHOD FOR CONTROLLING A BLOOD PURIFYING DEVICE

The present invention relates to a method for automatically controlling a blood filtration and/or purification device applied to a patient with renal insufficiency in order to eliminate one or more harmful substances from the blood. In such a device, especially, the invention concerns more particularly a method for controlling and regulating the flow rate of the extracorporeal blood circulation, the flow rate the of filtration of a fluid and/or soluble wastes from the blood, and, if necessary, the infusion flow rate of one or more substitution products and/or medications. The method also applies with some adaptations to peritoneal dialysis, which utilizes the human peritoneum as a filter. Several devices exist, each utilized for a particular need.

A first device utilizes a filter which is an apparatus divided into two compartments by a semi-permeable membrane. One of these compartments is connected to the patient by the extracorporeal blood circulation, and the second compartment is connected to a discharge line for the ultrafiltrate extracted from the blood and collected in a container created for that purpose. The operating principle of this device is based on the phenomenon of convection employing differential pressure in order to extract and eliminate excess water from the blood. This device is known under the name "ultrafiltration." It is particularly adapted for the rapid elimination of water and the simultaneous elimination of a limited quantity of metabolic wastes carried by the ultrafiltrate. This permits a suitable weight for the patient to be rapidly reestablished by eliminating excess water.

A second device called continuous or intermittent "hemofiltration" utilizes an installation identical to that previously described except that it is supplemented by a spontaneous or assisted line infusing one or more substitution products and/or medications into the blood circulation, which is then added to compensate for the quantity of ultrafiltrate extracted by taking the possible discrepancy in the more or less desired fluid weight or volume into account. This device also operates on the principle of differential pressure, but adding the substitution product allows a considerably greater extraction of metabolic wastes by allowing a longer treatment time.

A third method, called hemodialysis, is performed by connecting the inlet of the second compartment of a filter-exchanger to a reservoir of physiological solution which is caused to circulate in the second compartment, in counterflow to the blood circulation, while maintaining the pressure and flow rate relationship with respect to the blood circulation. The flow rate relationship is established to create conditions for diffusion through the semi-permeable membrane in the blood to the physiological liquid. Because of this physiological liquid circulation, the metabolic wastes are thus extracted, and more particularly, small molecules such as urea are eliminated.

These devices thus jointly comprise means for blood filtration divided into two compartments by a semi-permeable membrane wherein one of the compartments pertains to an extracorporeal blood circulation in which the flow rate is preferably imposed by a blood pump, and wherein the other compartment receiving the ultrafiltrate extracted from the blood is connected to a discharge line, a line in which the ultrafiltrate flow rate is also preferably regulated by an ultrafiltrate pump. When desired, these devices furthermore comprise one or more substitution product supply lines from a reservoir. Depending on the treatment and the type of filtration means utilized, the supply output of this line is either connected to the blood circulation through a mixer upstream or downstream of the filtration means, or connected to the second compartment of the hemofiltration means in counterflow to the blood circulation. The flow rate of the product in this line also may then be regulated by a product pump. Such a multipurpose device is for example described in document US 4 844 810.

Peritoneal dialysis is similar to the previous devices except that the blood circulation remains intracorporeal and that the human peritoneal membrane is used as the filtration means.

Furthermore, these devices comprise electronic monitoring and control means which, on the basis of measurements of the quantity of blood treated and/or ultrafiltrate extracted and/or product infused during a time period, monitor the pumps for regulating and adjusting the instantaneous flow rates of the circulation or different lines depending on the physician's instructions and the progression of treatment. Usually, these devices also comprise safety systems such as, for example, pressure transducers, for monitoring if the hemofiltration

or blood circulation means or one of the lines is obstructed or broken, and triggering a visual and audible alarm if necessary.

It is essential that the monitoring be performed very precisely to maintain hydric, calcium-phosphate, or other metabolic balances in the patient. In particular, in the case of long hemofiltration treatments, it should be able to treat not less than 40 liters of ultrafiltrate with an error rate of less than 200 milliliters, the equivalent of a glass of water, or to comply with an overall accuracy of less than 0.5 %. The known flow meters measuring volume per unit of time have proven to be very imprecise.

The document US 4 204 957 describes such a hemofiltration device in which the measurements of the quantity of ultrafiltrate extracted and substitution product supplied are performed by weighing by means of two scales respectively supporting the ultrafiltration collection container and the substitution product reservoir. To take into account possible variations in the flow rate of the liquids entering and exiting, the control method of the device consists of calculating at regular intervals the relationship between weight variations of the products during the interval, and comparing this relationship to instructions for deciding whether to modify a certain flow rate or other by adjusting the settings of the corresponding pump.

The document EP 321 754 describes another analogous hemofiltration device utilizing a high-precision scale for establishing the balance between the quantities of products entering and exiting, a volumetric pump, also high-precision, for monitoring the discharge line of the ultrafiltrate, and a peristaltic pump for monitoring the supply line of the substitution product. This device comprises two electronic circuits for separate microprocessors exchanging data on a duplex channel: a pilot circuit for the pumps and a monitoring circuit. The pilot circuit, comprising a data entry keyboard and a screen, receives the measurement signals from the scale and applies these monitoring signals to the ultrafiltrate and substitution product pumps. The monitoring circuit receives the measurement signals for the flow rate or rotation of each of the pumps. During implementation of the device, the pumps are calibrated, then the treatment data, particularly the overall treatment duration T, the quantity Q_{UF} of ultrafiltrate to extract and the quantity Q_{SUB} of substitution product are introduced into the pilot circuit by means of the keyboard.

The monitoring method thus consists of first calculating the necessary flow rates by the monitoring circuit. The method then consists of, at regular intervals, firstly calculating the remaining theoretical quantities by the pilot circuit on the basis of the calculated flow rates and the elapsed time as indicated by an internal clock, and to control the scale results wherein the measurement is also transmitted to the monitoring circuit. Secondly, the method consists of controlling, during each time interval, the operation of the pumps by the monitoring circuit, comparing the product quantities such as deduced from the scale signal and the pump signals and comparing the quantities against the theoretical quantities. Lastly, the method consists of adjusting the monitoring commands of the pumps if necessary for regulating their effective flow rates to the theoretical values. On the other hand, if at the end of a time interval the comparison results differ from a predetermined maximum limit value, an alarm is triggered.

The document WO 93/06875 describes another analogous hemofiltration device comprising a scale for measuring the extracted ultrafiltrate and the substitution product reservoir. The monitoring method consists of only operating the substitution product pumps and the ultrafiltrate pumps when the blood circulation pump is operating. At regular intervals, the weights of the residual substitution product in the reservoir and the extracted ultrafiltrate are measured and compared to the corresponding predetermined theoretical weights by the pilot circuit at the given interval that were programmed and stored in the circuit, in order to adjust the pump flow rates for the product and ultrafiltrate. If necessary, the flow rate of the blood circulation is also adjusted.

Even when operating correctly in principle, one may observe, however, that these devices may show disconcerting behavior, particularly during transitory periods on the occasion of a large variation in one of the measurements or following the introduction of a significant data correction. The users thus experience a certain duress in connection with such automatic devices, especially if the treatment duration is particularly long.

The goal of the present invention is an automatic monitoring and surveillance method for a blood treatment device which is precise and reliable whatever the type of treatment performed, and which, furthermore, is easy to implement by necessitating the fewest interventions likely to have errors from the user, and

which has consistent performance for inspiring the confidence of the patients and treating physicians.

These goals are achieved because of a control method for a device comprising

- A means for blood filtration divided into two compartments by a semi-permeable membrane wherein one of the compartments pertains to a blood circulation in which the flow rate is preferably imposed by a blood pump or the heart, and

Wherein the other compartment receiving the ultrafiltrate extracted from the blood is connected to a discharge line in a container, a line in which the flow rate of ultrafiltrate is measured by a means for weighing or measuring the volume of ultrafiltrate and/or by a means for directly measuring the flow rate, a line in which the flow rate of ultrafiltrate is also preferably regulated by an ultrafiltrate pump,

- One or more lines supplying substitution product from a reservoir, wherein the flow rate is measured by the means for weighing or measuring the volume of product and/or by the means for directly measuring the flow rate, the supply output of this line being either connected to the blood circulation through a mixer upstream or downstream of the filtration means, or connected to the second filtration means compartment in counterflow to the blood circulation, or connected to the blood circulation through a flow divider upstream and downstream of the filtration means, the flow rate in this product line preferably being regulated by a product pump,

- A means for electronic control which, firstly on the basis of the parameters established for the treatment and secondly on the basis of variables measured by the sensors, monitors the pumps at predetermined time intervals for adjusting the instantaneous flow rates of the blood circulation, the ultrafiltrate and the substitution product respectively,

Characterized in that it consists of, during implementation of the device and its operation, reviewing and if necessary modifying by the electronic control means

the treatment parameters according to the measured variables and the medical and/or physical data previously stored in the electronic storing means of the electronic control means so as to ensure that device operates accurately and smoothly.

The expression "maintaining an accurate and smooth operation of the device" is understood to refer to, for example, the automatic correction of errors appearing in the measurements of a sensor following a jolt or shock, or the correction of errors occurring during the introduction of medical parameters, or the automatic reduction in a monitoring command for an excessively strong pump due to a calculation result for an excessively significant correction, or the automatic absorption of oscillations from a pump monitoring command due to a measured value oscillating around a predetermined critical value, or another automatic adjustment of the parameters to maintain consistent performance of the device.

The term treatment parameters is understood to refer to firstly the parameters for the medical instructions for treatment to be carried out according to the particularities of the patient, such as the treatment duration T, the overall quantity Q_{UF} of ultrafiltrate to extract and/or its flow rate, the overall quantity Q_{SUB} of the substitution product and/or its flow rate, but also the quantity Q_{MED} of a medication infused, such as heparin, or a temperature setting for the blood heating means reintroducing the blood into the body of the patient. Also referred to is the physical configuration of the device, for example the type of tubing utilized. Secondly, treatment parameter is understood to refer to the operation parameters for the device, in particular the calibration values (gain G, initial offset do) of each of the sensors present: scale or weight indicator for measuring weight, manometer for measuring pressure, peristaltic pump rotation sensors, but also the time interval Δt between two regulation cycles, the set parameter of flow rate D_{ij} applied to the circulation pump or the line j, the percentage of correction allowed, the maximum acceptable difference between the theoretical and measured values, or others.

According to a first example of application, the method according to the invention consists of, when changing a container on a scale, for example when changing an empty substitution product reservoir for a full reservoir or a full ultrafiltrate collection container for an empty container, reading and recording the measured weight values before, during and after changing, to detect the

stable measurements corresponding to the initial, empty, and end states, and to recalculate the parameters for gain G and offset do of this scale.

Thus, if a scale is altered following a shock or jolt, the scale is recalibrated from the next container change, which prevents taking erroneous values into account over a long period. In the case where the empty value proves to be aberrant, signifying that the damage to the scale is too significant to be corrected, an alarm may be triggered. The technical calibration knowledge thus pre-stored permits an automatic calibration to be triggered dynamically throughout the treatment and not only at the end.

According to a second example of application, the method consists of establishing at time i the parameter Δt_{ij} of the time interval between two adjustment monitoring operations of the flow rate of a pump i inversely proportional to the last effectively measured weight variable pd_{ij} or flow rate variable db_{ij} of this pump. In other terms, if the flow rate of a pump is low, the duration of the interval between two adjustments is long, while if the flow rate of the pump is significant, the interval is short and the adjustments are very close together. For example, an adjustment for pump j is not triggered except when the variation in measured weight $(pd_{j+1,j} - pd_{ij}) / \Delta t_{ij}$ of the corresponding liquid is greater than a defined value M, dependant in particular on the resolution of the scale; or once the maximum predetermined duration D for the interval has been reached. This pre-stored knowledge base of a best adaptation for a time interval between adjustment cycles thus allows the transitory situations to be much better controlled.

According to a third example of application, the method consists of, during the monitoring of interval Δt_{ij}, and following either firstly a measurement of a weight value pd_{ijmes} or flow rate value db_{ijmes} performed in the circulation or the line j leading to the observation of a significant error aij between the theoretical weight pd_{ijth} expected at time i and the effectively measured weight pd_{ijmes}, (or aij = $pd_{ijth} - pd_{ijmes}$ or according to the measured flow rate $db_{ijth} - db_{ijmes}$), or secondly a calculation following a manual entry in the device of the value of an exceptional gain or loss, involving a significant correction $\Delta Dbt = Db_{ij} - Db_{i-1,j}$ for a new setting parameter Db_{ij} for the corresponding pump j, limiting this set parameter for pump j to a value Db_{ijcorr} so that the increase ΔDbt_{corr} is limited to

a predetermined percentage P % stored as a knowledge base for consistent operation.

For example, it may be that, everything else also being normal, the extraction of the ultrafiltrate is momentarily slower since the filter is blocked. According to another example, it happens that the pumps are stopped during a procedure on the device while the patient remains under perfusion. After an hour, the patient may have "swollen" by 300 milliliters. This significant volume must then be deducted during the following adjustments wherein the values are considerably modified. Then, this monitoring method prevents the ultrafiltrate line pump from racing excessively, but allows the flow rate of this pump to be progressively increased. By thus avoiding apparently irrational behavior, the confidence of the personnel towards the device is considerably increased. This method may also occur following the introduction of information on the patient orally taking in a quantity of water which momentarily destabilizes the theoretical hydric equilibrium, the said destabilization may very well be compensated for over a long period preferably to a short period leading to the racing of one of the pumps. Preferably, this method is optional so it may be disengaged if the personnel know in advance that the particular treatment conditions are on the point of intervening. This method may be supplemented by a control method of the convergence of hydric equilibrium toward its theoretical value.

Contrary to the previous state, the adjustment of a flow rate Db_{ij} is no longer performed only on the basis of a measured value, but in combination with the knowledge base, in this case the preferred limitation data for acceleration previously established during implementation of the device.

According to a forth example of application, the method consists of, during the introduction of a parameter into the electronic control means, comparing the entered value of the parameter to a range of tolerable values contained in the pre-stored knowledge base, and to maintain this parameter at the initial value if the new value is beyond the range.

For example, during implementation of the device, treatment parameters such as the parameters q_{MED} of quantities of medications to infuse during the duration T of treatment are introduced. The method thus consists of verifying that the value entered pertains to a safety range $(q_{MedMin} - q_{MedMax})$ defined for

example by the manufacturer of the medication and previously stored in the memory. According to another example, the user manually enters the value of a loss or gain allowing it to be taken into account throughout the hydric equilibrium of the patient. It is easy to make errors by a factor of 10, for example by writing 1000 ml in place of 100 ml. The 900 ml difference is then automatically added or withdrawn from the patient by the subsequent operation of the device dangerously modifying the hydric equilibrium. These pre-stored knowledge banks of medical risks allow crisis situations to be automatically prevented.

According to a fifth example of application, the method consists of, during the measurement of a value situated outside an accepted range of values, modifying data indicating the presence of an error in the pre-stored knowledge banks, recording the suspected value in the data storage means, and restarting a new measurement. This also is applicable to a command that was not followed.

Owing to this method, the incidents of operation recuperated simply by repeating the instructions are nevertheless recorded in the pilot circuit storage means, the history of these incidents thus accumulated allow a subsequent breakdown to be better distinguished and diagnosed. Typically, the weight or pressure sensors may at first present intermittent breakdowns that are subsequently undetectable, but whose accumulation allows the conclusion that the aging of said sensor necessitates that it be replaced preferably in advance.

The knowledge banks established when the device is constructed may be periodically revised and improved, for example on the occasion of a revision of the device or following the appearance of new medications or when discovering new medical results.

The invention and its advantages will be better understood upon reading the following detailed description, done in reference with the attached simplified diagram of a device for purifying blood, presented only for illustration and not to be limited.

The figure illustrates a patient 19 suffering from renal insufficiency and whose blood purification must be performed extracorporeally. For this purpose, the

patient is connected to an external blood circulation comprising following a conduit 20 for removing and discharging blood, a blood pump 1 which may be a peristaltic pump, hemofiltration means 8 and a conduit 21 for returning the blood to the patient.

The blood filtration means 8 appear in the form of a chamber separated into two compartments by a central membrane: a compartment 8a crossed by the blood circulation and a compartment 8b in which the ultrafiltrate extracted from the blood appears. This compartment 8b is connected by a line 24 to an ultrafiltrate extraction pump 4, which line is subsequently directed to a collection container 17. By adjusting the flow rate of pumps 1 and 4, a pressure differential may be created between the compartments 8a and 8b causing a displacement by convection of the ultrafiltrate through the membrane of filtration means 8. The pump 4 may be a peristaltic pump or a volumetric pump, but remains optional.

Furthermore, the device comprises a reservoir 15 for a first substitution product and/or medication, which is infused into the blood circulation upstream from the hemodialysis means 8 through a line 25 inside of which the flow rate is preferably controlled by a pump 2. In the case of hemofiltration, the supply end of line 25 is connected through a mixer 22' to the conduit 20 of the blood circulation, for example downstream of pump 1 this product then passes the filtration means in compartment 8a. In the case of a hemodialysis treatment, the supply end of line 25 is diverted by a line 25' for connecting the filtration means 8 in the second compartment 8b for purifying the blood.

This device may furthermore comprise a second reservoir 16 for a second substitution product and/or medication provided for being infused into the blood circulation downstream of filtration means 8. For example, this second product is carried by a conduit 26 and a product pump 3 to a mixer 22 inserted in conduit 21.

In another configuration, not illustrated, the product may be carried from the container 15 by means of the pump 2, a flow divider adjusting the ratio between the flow rate of the substitution product infused into the blood circulation upstream of the filtration means 8 and the flow rate of substitution product infused into the blood circulation downstream of filtration means 8.

One or more pressure sensors 30 installed on line 21 allow the satisfactory operation of the apparatus to be monitored, in particular the filtration means 8, the condition of the tubing and their connections as well as that of the patient, and to anticipate possible problems, in particular blood coagulation at the membrane, or an obstruction in upstream line 20. A sensor, not shown, connected on line 24 may monitor the desired absence of blood in the ultrafiltrate.

In order to rigorously maintain the hydric and metabolic equilibriums of the patient 19, this device is controlled by electronic means 9-14 which, on the basis of measurements of sensors 2'-3'-4', 5-6-7 exactly monitor the flow rates applied by the pumps 1-4 in the blood circulation and their corresponding lines.

The electronic means comprise a central pilot circuit 9 including a microprocessor, this circuit being accessible by a keyboard 14 and showing the data on the display means such as a screen 13. This central pilot circuit 9 is duplicated by a monitoring circuit 10 also comprising a microprocessor with which it is connected on a bidirectional data transfer line, and exercises direct control on the motors and sensors. This pilot circuit 9 is also connected through a data transfer bus firstly with the first electronic means 11 for storing parameters, for example RAM circuits for storing parameters specific to the treatment and software for implementing the control method of the device, and secondly with a second electronic means 12 for storing general knowledge bases, for example in the form of an EPROM or Flash-PROM circuit. The data of these two storage circuits 11 and 12 may be accessible to the monitoring circuit 10 through a duplex channel.

In order to monitor the course of treatment, the device comprises firstly scales, respectively a scale 5 supporting the reservoir 15 of the first product, a scale 6 supporting the reservoir 16 of the second product and a scale 7 supporting the collection container 17 of the ultrafiltrate. These scales may be strain gauge and electronic treatment scales emitting electronic measurement signals pd_{ij} transmitted to the central pilot circuit 9 through a preamplification and adaptation circuit (input/output) 9'. Similarly, the rotation encoders or other flow rate sensors 2', 3' and 4' respectively connected with the infusion pump 2 for the first product, with infusion pump 3 for the second product, and with extraction pump 4 for the ultrafiltrate, generate electrical signals db_{ij} which are transmitted

to the monitoring circuit 10 through a preamplification and adaptation circuit (input/output) 9"'. The pilot circuit 9" applies the instructions to an interface card 9 emitting settings D_{ij} to each of pumps 2, 3 and 4.

Thus, on the basis of pilot circuit 9 weight pd_{ij} and flow rate db_{ij} measurements, under the control of a procedure such as transcribed by software loaded into the memory 11, performed at regular intervals Δti of the adjustment cycles, that is, that during this cycle it acquires measured values pd_{ij} and db_{ij} for comparison to theoretical values corresponding to time t and, in case of drift, applying the new settings D_{ij} to the corresponding pump. In particular, this control method comprises a starting sequence then, during each cycle, a value acquisition sequence, an adjustment calculation sequence and a safety verification sequence.

More particularly according to the invention, this device control procedure is not done only on the basis of treatment parameters recorded in the memory 11 and measured sensor values, but also on the monitoring and response of general medical-type knowledge banks related particularly to the treatment methods and products used, and technical knowledge related in particular to the technical characteristics of the scales and pumps, this in order to ensure both reliable operation, that is, without risk of causing a fatal crisis for the patient due to a dysfunction of the device but also an aforesaid smooth operation, that is, not triggering apparently aberrant behavior, even if justified.

In a first starting sequence, the central circuit 9 proceeds with an electronic test of the different components of the device, that is, it verifies if it obtains effective access to the scales, encoders, pumps, even to several safety pressure sensors like, for example, sensor 30 verifying that the blood circulation is not obstructed or broken.

Circuit 9 then proposes on screen 13 treatment choices wherein the responses are introduced by the user by means of keyboard 14. The user may then choose the duration T of treatment, the quantity Q_{UF} of ultrafiltrate to extract, the quantity Q_{SUB} of the substitution product and/or medication to add. More particularly according to the invention, each of these choices expressed by the user is verified compared to the medical knowledge recorded in the memory 12. In particular, if according to the entered quantity Q_{UF}, the user introduces an

excessively high quantity Q_{SUB}, the circuit 9 detects that this introduced value is situated beyond a predefined range in the general knowledge and refuses to validate this entry, that is, this entry is not written into the memory 11 by reporting the user.

It must be noted that keyboarding the parameters may also occur in the course of treatment, for example when one wants to introduce an exceptional hydric gain or loss to the patient. Then, circuit 9 also compares these values in comparison to a range of probable values contained in the general knowledge situated in value 12. Thus introduction of an aberrant value is avoided, for example 1000 milliliters in place of a value of 100 milliliters corresponding to a glass of water normally taken in by the patient.

The starting sequence is then followed by a rinsing procedure of the blood circulation and supply and discharge lines then, following connection to the patient, the treatment as such is started.

It often occurs that, in the course of treatment, one of the empty product reservoirs and/or the full ultrafiltrate collection container must be changed. More particularly according to the invention, the pilot circuit 9 uses this change to proceed with verification of the calibration of the corresponding scale. In particular, the pilot circuit starts by triggering an alarm when it detects that the measured weight of a reservoir falls below a predetermined lower limit or that the measured weight of a container exceeds a predetermined upper limit. It then triggers a continuous acquisition phase of the measured weight value, which value is accumulated in a memory. Following the changing of the reservoir or container by the user, the pilot circuit 9 detects significant variations in the measured weight values and analyzes the sequence for identifying the last measured value of the old reservoir or container, the empty value of the scale and the new value of the container or reservoir. If the empty value proves to be too high, the pilot circuit 9 then declares this scale to be too unstable and requires a recalibration by a technician. If the empty value remains lower than the predetermined value, the pilot circuit redetermines the empty offset o0 to subtract from the measured value as well as the calibration gain G to apply for obtaining a corrected measured value. The pilot circuit, detecting that the conditions are again brought together for treatment, automatically restarts the treatment. Thus, owing to the technical knowledge stored by the memory 12,

the pilot circuit 9 can minimize user intervention to simply replacing the container while using this change for increasing the measurement precision by recalibrating. The harmful effects of a jolt or shock to the scale are then thus periodically eliminated.

In addition, the central pilot circuit 9 comprises an internal clock whose counting of impulses allows it to determine the elapsed time t since the start of treatment. At time intervals Δ_{ti}, this pilot circuit triggers an adjustment cycle. This cycle starts by acquiring the measured weight pd_{ij} values at this time t for each of scales ∫for the first product, second product and ultrafiltrate. The circuit may then calculate the variation in weight Δp_{ij} during the last elapsed interval Δ_{ti}. At the same time, the pilot circuit calculates from the introduced flow rate parameters Q_{UF}/T or Q_{SUB}/T the theoretical variation in expected weight, and does this by taking account of the evaluation assessment from the previous interval. The flow rate D_{ij} is then increased or decreased according to the difference between the expected weight and the measured weight. The modification of a parameter by the user is immediately taken into account, without which it would be necessary to wait for the next adjustment.

At the same time, the monitoring circuit 10 acquires the measured values db_{ij} from the transducers 2', 3' and 4' on its input/output circuit 9". This monitoring circuit may, by calculating the time interval Δ_{ti}, also measure in a second way the variations in weight of the product and/or ultrafiltrate. A data exchange between the pilot circuit 9 and the monitoring circuit 10 allows the verification that the variations in weight measured from the scales are equivalent to the values of weight measured from the transducers at an inaccuracy close to these last results. In case it is positive, the decision to adjust the corresponding flow rate is validated. Conversely, the significant difference between the weight variation value from the scales and from the encoders means that one or the other of these latter elements presents a significant defect necessitating the triggering of an alarm for verification by a technician.

More particularly according to the invention, this new flow rate setting D_{ij} is furthermore reevaluated according to the general knowledge stored in the memory 12 which imposes a limit on a value Db_{MAX}, for example 40 % of the theoretical value, knowing that a larger correction, even if justified, may arouse the patient's and/or the user's concern to the risk that it is erroneous. Thus, the

application of this general knowledge tends to limit the correction for the following interval, for example to a maximum of 40 % of the last known value for the flow rate, this correction then being automatically spread out in time.

Preferably, this knowledge also triggers an alarm in the event that this correction limitation occurs beyond a predetermined number of time intervals, and does this for preventing this limitation from creating a discrepancy in the detected weight difference. The user may then choose to manually disengage this safety feature in complete knowledge of its cause.

According to another important aspect of the invention, the usually consistent time interval Δ_{ti} is, in this device, reevaluated according to a function pertaining to the general knowledge stored in the memory 12. More particularly, the following time interval Δ_{ti} is established in a way that is inversely proportional to the last measured flow rate variable db_{ij}, or preferably to the last evaluation of the variation in weight divided by the last effectively measured time interval for the circulation or line j ∫ In other terms, an adjustment is not triggered unless when the variation in weight Δ_m reaches a predetermined value M according to a more or less long time interval Δ_{ti}. Then the adjustment cycles are more spaced out according to the long intervals Δ_{ti} for a slow-flow rate line, and markedly closer together for a higher flow rate line. This allows the transitory situations in one direction as in another to be better controlled.

Particularly, according to a method of the invention implemented by the pilot circuit 10, an adjustment cycle for pump j is not triggered unless when the variation in weight pd_{ij} / Δ_{ti} measured since the last adjustment becomes greater than a value M defined depending in particular on the resolution of the scale. This avoids causing oscillations in adjustments uniquely due to the measuring uncertainty of the scale around this measurement. Preferably, this delay in weight variation in time is limited to a time D defined in the general knowledge banks stored in the memory 12. Thus, the knowledge of oscillating phenomena in the monitoring of the device due to the measuring uncertainty is absorbed in the method according to the invention.

In addition, it may happen that a measured value for the scale, encoder, flow rate transducer or pressure sensor is a manifestly aberrant value. Usually then, the pilot circuit rejects this value and triggers a new measurement for not taking

into account these unwanted measurements due to a momentary defect of the corresponding sensor. More particularly according to the invention, the time i and the aberrant value pd_1 are stored in a history file of the device allowing, during a revision of the device, to detect intermittent breakdowns as well as their frequency for a given sensor, facilitating its replacement before complete failure. In particular, a repetition that is increasing in time of the appearance of aberrant values may be detected by the pilot circuit 9 according to a procedure stored in the knowledge banks in the memory 12. This detection of error repetition allows a risk of failure warning message to be triggered.

The general knowledge banks are preferably developed for a plurality of families of elements: families of scales, pumps, and membranes for hemofiltration means, and this is performed by collecting data provided by the respective manufacturers so that changing an element for another in its family is facilitated.

CLAIMS

1. A method for controlling a device comprising

- Means for filtrating blood (8) divided into two compartments by a semi-permeable membrane

Wherein one of the compartments (8a) pertains to the blood circulation (20, 21) in which the flow rate is preferably imposed by a blood pump (1), and

Wherein the other compartment (8b) receiving the ultrafiltrate extracted from the blood is connected to a discharge line (24) in a container (17), line in which the flow rate of ultrafiltrate is measured by the means for weighing (7) or measuring the volume of ultrafiltrate and/or by the means for directly measuring the flow rate, line in which the flow rate of ultrafiltrate is also preferably regulated by an ultrafiltrate pump (4),

- One or more supply lines (25, 26) of a substitution product from a reservoir (15, 16), wherein the flow rate is measured by means for weighing (5, 6) or measuring the volume of the product and/or by means for directly measuring the flow rate, the supply outlet of this line being either connected to the blood circulation through a mixer (22) upstream or downstream of these means for filtration (8), or connected to the second compartment (8b) of the means for filtration in counterflow to the blood circulation, or connected to the blood circulation through a flow divider upstream and downstream of the means for filtration (8), the flow rate in this product line preferably being regulated by a product pump (2, 3),

- Means for electronic control (9-14) which, firstly on the basis of the parameters established for the treatment and for the machine and secondly on the basis of variables measured by the sensors (5, 6, 7, 2', 3', 4'), monitor the pumps at predetermined time intervals to adjust the instantaneous flow rate of the blood circulation, the ultrafiltrate and the substitution products respectively,

Characterized in that it consists of, during implementation of the device and during its operation, revising and, if necessary, modifying by the electronic control means (9, 12), the treatment parameters according to the measured variables and the medical and/or physical knowledge banks previously stored in the electronic storing means (12) of the electronic control means so as to ensure that device operates accurately and smoothly.

2. The method according to claim 1, characterized in that, when a container (15, 16, 17) on a scale (5, 7, 6) is changed, the measured weight values are read and recorded before, during and after the change, the stable measurements corresponding to the initial state, empty state and final state are detected, and the gain and offset parameters of this scale are recalculated.

3. The method according to claim 1, characterized in that it consists of establishing at a given time the time interval parameter between two monitoring operations for adjusting the flow rate of a pump in an inversely proportional manner to the last effectively measured flow rate variable for this pump or to a given flow rate setting.

4. The method according to claim 1, characterized in that it consists of triggering a pump adjustment only when the measured weight variation of the corresponding liquid is greater than a defined value or when a maximum time interval duration has been reached.

5. The method according to claim 1, characterized in that it consists of, following a measurement, calculating a weight or flow rate value performed in the circulation or a line leading to the detection of a significant error between the theoretical weight expected at this time and the effectively measured weight involving a significant correction of the new setting parameter for the flow rate of the corresponding pump, limiting this setting parameter for the pump to a corrected value so that the increase in flow rate is limited to a predetermined percentage stored in a knowledge bank for consistent operation.

6. The method according to claim 1 characterized in that it consists of, during the introduction of a parameter in the electronic control means, comparing the entered value of the parameter to a range of tolerable values contained in the knowledge banks, and maintaining this parameter at its initial value if the new value is beyond the range.

7. The method according to claim 1 characterized in that it consists of, during measurement of a value situated outside the range of acceptable values, modifying data indicating the presence of an error in the pre-stored knowledge banks, recording the suspect value in the data storing means, and restarting a new measurement.

8. The method according to claim 1, characterized in that the medical and/or physical knowledge banks previously stored in the electronic storing means (12) may be modified or acquired during the treatment.